while adjusting the heat-up rate to 0.5 to 10 °C /minute at least within the temperature range of 700-850 °C. In this first heat treatment, the formation of minute precipitation nuclei and the growth thereof are promoted by the controlled heat-up procedure (ramping) from a low temperature, see paragraph [0055] of the published application.

In the second heat treatment, it is essential that 1 to 2 hours of heat treatment at 1150 °C or above be followed by temperature lowering to 1000-1150 °C and further followed by 2 to 10 hours of heat treatment in that temperature range. The second heat treatment is carried out for the purpose of outward-diffusion heat treatment and for promoting the growth of precipitates, see paragraph [0056] of the published application.

In the present invention, an effect on controlling the oxygen donors can be exerted by combining the first step, in which the controlled heat up procedure or ramping from a low temperature at low speed is performed, with the second heat treatment.

In review, all claims are rejected under 35 U.S.C. § 103(a) based on the combination of EP 1,087,041 to Abe when modified by JP 2000-344598 to Ikari and United States Published Patent Application No. 2004/0102056 to Tobe. The Examiner asserts that the only difference between the invention and Abe is the carbon concentration and the third annealing step. Ikari is cited to allege that the carbon concentration is obvious and Tobe is cited to allege that the use of the third annealing step is obvious. Applicants traverse the rejection on the grounds that Abe does not teach the first and second heat treatment and the secondary references do not remedy the failing in Abe. The traverse is set out under the headings of the applied prior art.

Abe

Abe is recognized in the specification as prior art. Abe teaches a silicon wafer having a resistivity of 100 Ω • cm or more. Abe has a two step heat treatment. The first is an oxygen precipitation heat treatment. The second is a device production heat treatment at 350-500 °C. Using the oxygen precipitation heat treatment as a precursor to the production heat treatment means that the resistivity of 100 Ω • cm or more in the wafer is maintained.

The problem with the method of Abe is addressed in paragraph [0011-0018] of Applicants' published application. Here, Abe corresponds to WO 00/55397. In brief, the oxygen precipitation treatment of Abe can result in a deterioration of the mechanical strength of the wafers. The present invention's object is to overcome the problems of Abe as detailed in paragraph [0019] of the application.

One issue of obviousness is whether Abe teaches the first and second heat treatments of claim 1.

In the rejection, the Examiner states:

> The Abe reference teaches a method of producing a high-resistance silicon wafer having a resistivity of 100 Ω • cm or more, oxygen concentration of 14×10^{17} atoms/cm^3 or more, remaining oxygen concentration of 12×10^{17} atoms/cm^3 or less by performing heat treatment performed at 700-900 °C for 5 hours or more, a heat treatment performed at 950-1050 °C or 10 hours or more, a heat treatment performed at 1100-1250 °C for 1-5 hours, and a density of a grown-in defect of 1×10^3/cm^3."

Specifically, the Examiner states that Abe does in fact teach the claimed two step heat treatment in the order claimed.

In Abe's oxygen precipitation heat treatment, a high temperature heat treatment

at 1100 °C or higher is performed in its first step so as to diffuse outward the interstitial oxygen in the surface of the wafer, see paragraph [0052] of Abe. Accordingly, Abe's heat treatment is different in order and further, in conditions from the two step heat treatment of the claimed invention. The method of claim 1 consists of a first heat treatment, in which the controlled heat-up procedure or ramping from a low temperature at low speed is performed, and a second heat treatment, which is carried out for the purpose of outward-diffusion heat treatment for promoting the growth of the precipitate generated from the first heat treatment.

While at first glance, Abe's heat treatment may appear similar to the heat treatment of the present invention when viewing Figure 3 of Abe. However, in Abe's heat treatment, a high temperature treatment is performed in the first step. In contrast and as mentioned above, the feature of the invention lies in the combination of the first and second heat treatments. That is, the first heat treatment, in which the heat-up is carried out in a controlled manner, i.e., ramping, at low speed, is combined with the second heat treatment, in which a high temperature heat treatment and a medium temperature heat treatment are performed.

In this regard, claim 1 requires a ramping up of the temperature from 700-850 °C at a temperature rise rate of 0.5 to 10 °C/min. Even at the highest rate, the ramp up would be 1500 minutes (25 hours) to go from 700 to 850 °C. The question is whether Abe teaches such a ramping up treatment in the claimed range.

In the rejection, the Examiner points to Example 4 of Abe to allege that the claimed heat treatment sequence is taught. However, Example 4 merely describes a three step heat treatment, 4 hours at 500 °C in a nitrogen atmosphere, 6 hours at 800

°C in a nitrogen atmosphere, and 10 hours at 1100 °C. There is no discussion of a ramping between 700-850 °C whatsoever in Abe or a control of the temperature in terms of a temperature increase over time. Therefore, the Examiner has committed error in relying on Example 4 as evidence that the specific heating steps of claim 1 are taught in Abe.

While Abe discloses adjusting the heat up rate to 10 °C/min in the controlled heat-up procedure, Abe does not disclose the condition of the controlled heat-up or ramping at the claimed low speed at the specific temperature range of claim 1.

In fact, Abe discloses a high temperature treatment for the oxygen precipitation. This is evident from Example 4, wherein the third heat treatment at 1100 °C is also part of the oxygen precipitation treatment. Example 4 can be contrasted with Example 1 of the invention. In example 1 of the invention, the wafer is charged to a 700 °C furnace and heated up slowly until the target temperature of 900 °C is reached. The wafer is then heated at 1 hour at 900 °C. The second heat treatment is then practiced, wherein the wafer is heated to 1200 °C for 1 hour. Comparing Example 1 of the specification and Example 4 of Abe reveals that the ramping up used in the invention is not taught or suggested in Abe.

The importance of the ramping up of the invention cannot be underestimated or dismissed. As explained in paragraphs [0058-0063], the ramping up treatment forms oxygen precipitate nuclei within the wafers and improves the density of oxygen precipitation nuclei.

The two step heat treatment of the invention is also beneficial. The wafer resistivity is maintained as explained in paragraphs [0075 and 0076].

The residual oxygen concentration of wafers must also meet ASTM standards, see paragraph [0077] of the published application. By practicing the invention, these standards can be met, see Table 1 and paragraph [0086].

The importance of the first step of heat treatment is also explained in paragraphs [0105 and 0106], wherein the growth of minute precipitated nuclei can be sufficiently promoted as a result of the ramping up heating.

The invention is not merely tweaking the temperatures used in Abe, but a completely different approach to the Abe method. The specification acknowledges Abe as prior art and indicates that Abe's method of heating is deficient. In spite of the identification of Abe as a prior art process that is improved by the invention of claim 1, the Examiner continues to insists that the invention is essentially the same as Abe but for two minor points of carbon content and a third heat treatment step.

When closely comparing the invention to Abe reveals that Abe's heating is not the same as that employed in the invention. In Abe, a high temperature heat treatment is performed as the first oxygen precipitation step, whereas the critical nature of the invention lies in the combination of the ramping up of the first heat treatment with the high temperature second heat treatment. That is, the first heat treatment, in which the heat-up is carried out in a controlled manner at low speed, is combined with the second heat treatment, in which a high temperature treatment and a medium temperature treatment are performed. The conditions used for the two step heat treatment are just not specifically disclosed in Abe.

At best, the Examiner can only assert that there may be overlap in some of the temperatures used in the invention and Abe, and that there may be overlap with

respect to the heat-up rate disclosed in Abe and the invention. Even with this overlap, the Examiner must still conclude that one of skill in the art would decide to modify Abe and choose the particular ramp up heating temperature and rate of the first heat treatment of claim 1. However, why choose this particular mode of operation in Abe, when Abe is not in the least concerned with the aim of the invention or the ramp up leading to the high temperature heat treatment? The Examiner does not have a legitimate factual basis for modifying Abe absent knowing the invention beforehand. A rejection of this nature smacks of hindsight and such a rejection could not be sustained on appeal.

In fact, Abe does not teach the claimed first and second heat treatments and there is no reason to modify Abe in such a fashion to practice the method of claim 1.

Moreover, the specification demonstrates that practicing the invention provides improvements in the wafer production and these improvements are not expected given the teachings of Abe. These improvements are further substantiation that the invention of claim 1 is not obvious based on Abe.

Since Abe does not teach the claimed first and second heat treatments, a *prima facie* case of obviousness is not established unless the secondary references can make up for the failings in Abe. As shown below, this is not the case.

<u>Tobe</u>

Tobe relates to the control of the amount of oxide precipitates in a silicon wafer. Tobe performs heat treatment (RTA) to a silicon wafer with a rapid heating-rapid cooling apparatus. Thereby, atomic vacancies are injected from a surface of the wafer

to form a maximum position of an atomic vacancy concentration in a depth direction in the vicinity of the surface of the wafer. Tobe then performs heat treatment (post annealing) to move the maximum position of the atomic vacancy concentration in the vicinity of the surface of the wafer into the inside of the wafer, see claim 1, thereof.

Tobe's RTA treatment is performed in a temperature range of 1100-1350 °C followed by post annealing in a temperature range of 700-1050 °C. Therefore, the heating conditions of the RTA treatment and post annealing of Tobe are completely different from those of the two step heat treatment of the invention. Tobe performs oxygen precipitation heat treatment after the RTA treatment. In the second step of the oxygen precipitation heat treatment of Tobe, the heating temperature is lowered as opposed to the present invention, wherein the heating temperature is raised.

Further, the heat-up rate of the present invention is adjusted in the temperature range of 700-850 °C. This adjustment results in the formation of oxygen precipitation nuclei within the wafers and improvement of the density of oxygen precipitation nuclei, see paragraph [0058] of the published application. Tobe fails to teach or suggest this feature. Thus, even if Tobe were combined with Abe, the invention can still not be practiced.

Applicants also submit that since the processing of Tobe is not similar to the invention or Abe, one of skill in the art does not have a proper reason to conclude that the particular heat treating step of Tobe can be used in Abe. The Examiner is merely noting that a third treatment is used in Tobe and because of this, one would use it in Abe to attain the benefits of Tobe. The Examiner is concluding obviousness but only noting the presence of the claimed medium temperature treatment, but not defining the

articulated reasoning why Abe can be modified using Tobe. Thus, this aspect of the rejection is also improper and a *prima facie* case of obviousness is not established for this reason.

Ikari

Ikari relates to the production of wafers for MOS devices having precipitation defects in high density at the center of the thickness direction of a substrate as to exert an excellent gettering ability. To achieve this, Ikari subjects the obtained silicon semiconductor substrate to heat treatment in a non-oxygenated atmosphere in a temperature range of 1000-1300 °C for an hour or more, see claim 2 thereof.

Therefore, even if Ikari discloses the carbon concentration of the claimed invention, it cannot be concluded that it teaches the carbon concentration of the wafers applied in the two step heat treatment of claim 1. Thus, Ikari does not cure the failing in Abe and even if combined therewith, a *prima facie* case of obviousness would not exist.

Summary

The present invention is characterized by the combination of the first and second heat treatments. That is, the first heat treatment, in which the heat-up is carried out in a controlled manner or ramping at low speed is combined with the second heat treatment, in which the high temperature treatment and medium temperature treatments are performed. None of Abe, Tobe, or Ikari teaches or suggests the details of the two heat treatments, and particularly the ramping up of the first heat treatment

and following of the first heat treatment with the second heat treatment.

Accordingly, the Examiner is requested to examine this application in light of this response and pass claim 1 and its dependent claims onto issuance.

If the Examiner believes that an interview would be helpful in expediting the allowance of this application, the Examiner is requested to telephone the undersigned at 202-835-1753.

The above constitutes a complete response to all issues raised in the Office Action dated February 18, 2010.

Again, reconsideration and allowance of this application is respectfully requested.

Please charge any fee deficiencies to Deposit Account No. 50-1088.

Respectfully submitted,
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